

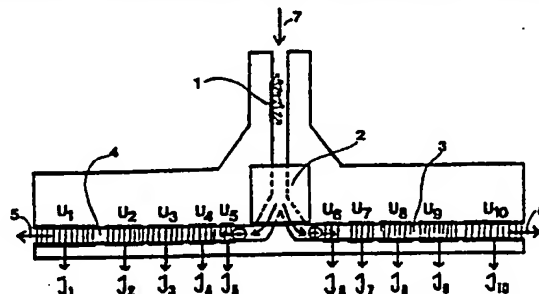


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904997 11 October 1990 (11.10.90) FI(71) Applicant (for all designated States except US): **PUUMALAINEN CONSULTS OY [FI/FI]; Linnankatu 28, SF-57130 Savonlinna (FI).**

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(75) Inventor/Applicant (for US only) : **PUUMALAINEN, Pertti [FI/FI]; Linnankatu 28, SF-57130 Savonlinna (FI).**(74) Agent: **PITKÄNEN, Hannu; Savilahdentie 6 A, SF-70210 Kuopio (FI).**(81) Designated States: **AT (European patent), AU, BE (European patent), BR, CA, CH, CH (European patent), DE, DE (European patent), DK (European patent), ES (European patent), FR (European patent), GB, GB (European patent), GR (European patent), IT (European patent), JP, KR, LU (European patent), NL (European patent), SE (European patent), SU⁺, US.****Published***With international search report.**In English translation (filed in Finnish).*(54) Title: **METHOD FOR DETECTION OF ALIEN MATTER CONTENTS IN GASES**

(57) Abstract

The objective of the invention is a method for detection of alien matter contents in gas, in which method the gas and the substances contained in it are ionized in an ionization room (1). By the present methods impurities in gases cannot be determined fast and in small concentrations. In the method of the invention the ions contained in the gas are separated in a separation section (2) into positive and negative ions, of which at least the ions of either sign are led into a narrow analyzer channel (4). There, due to the capillary force, they are forced to move in the middle section of the channel, from where they are deflected by electric fields of different strength caused by different voltages (U_1 - U_{10}) into an electrode located at the edge of the channel, where they cause ion current (I_1 - I_{10}). On the basis of the ion currents a current spectrum is made, on the basis of which different substances are detected and their concentrations determined with the aid of corresponding spectra obtained with standard samples of different substances.

+ DESIGNATIONS OF "SU"

Any designation of "SU" has effect in the Russian Federation. It is not yet known whether any such designation has effect in other States of the former Soviet Union.

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METHOD FOR DETECTION OF ALIEN MATTER CONTENTS IN GASES

The object of the invention is a method for detection of alien matter contents in gases, in which method the gas is first ionized and alien matters are detected and determined
5 by the behaviour of formed ions.

Alien matter contents are often detected and determined in order to control that the air is safe to breath. Particularly, when analyzing certain very poisonous substances, which appear in small quantities, other substances of air
10 may disturb detection. The quantities of different substances, such as carbon dioxide, may vary in air. The detection of different molecules or molecule groups from gases or vapour of vaporized solid or liquid materials is often connected with problems. Particularly, detection of
15 poisonous substances, such as nerve gases spread in the air, reliably and fast enough from small quantities, is difficult. The detection should be made in a few seconds and, with the most effective nerve gases, from concentrations as small as 1/100 ppm.

20 At present the most sensitive analyzing devices are based on ionizing the air for example by alfa or beta radiation and measuring the ions in different circumstances. In one method, the ions are made to penetrate through a certain kind of a labyrinth and the remaining ions are measured from
25 the current they generate. Another method observes the mobility of the ions through different grids and finally ion current is measured. By these two methods very heavy molecules, such as most combat gases, can be detected from air. In one method ionized molecules are led through chambers,
30 which have different electric fields, and the nature and concentration of the molecules of alien matters are tried to be detected by measuring the current from these electric fields. This method is rather efficient, but the recombination of different charges is a problem, because it makes

ions disappear faster.

The aim of the invention is to bring about a method for the detection of alien matter contents in gases, by which the nature and quantity of different alien matter components in a gaseous state are measured and detected, even small concentrations, such as below 1 ppm. In particular the purpose of the invention is to bring forth a method, by which the consistency and quantity of nerve gases or other similar gases can be detected quickly and early.

10 The aim of the invention is achieved by a method, the characteristics of which are presented in the claims.

In the method according to the invention the gas and the different substances contained in it are ionized in a ionization room by applicable radiation, for instance by alfa radiation. After this the gas is transferred into a separating part, where the ions in the gas are separated into positive and negative ions. At least the ions with one sign are led into a narrow analyzing channel, in which they are forced to move in the middle section of the channel because of the capillary force. From here they are taken by electric fields of different strength to an electrode located at the edge of the channel, where they cause ion current. On the ground of the ion currents a current spectrum is calculated, from which different substances are detected and their concentrations determined with the aid of corresponding spectra calculated from standard samples of different substances. The analyzing channels are made narrow, so the ions move in them without losses, even distances of several tens of meters, especially when they are well separated from the ions with opposite sign. This is the so called capillary transportation, which is known from some ion transportation equipments used in nuclear physics. In the capillary space the ions are deflected with different electric fields away from the carrier gas, small and highly

charged ions or particles are deflected by a low voltage, while large molecules or particles with a small charge require a high voltage. When this is done in both channels, we get a spectrum, in which for example x-axis is the voltage from negative (deflection of positive ions) to positive (deflection of negative ions), and y-axis is the ion current measured from corresponding deflection spot. From this spectrum different substances can then be detected based on the spectra of standard samples.

The method is functioning in atmospheric pressure or in underpressure. The air can be filtered mechanically before the analysis or, for example moisture can be removed. Often the air is also heated in order to vaporize the aerosol particles contained in it. If liquids are analyzed, they are first brought into a gaseous state by lowering the pressure and/or heating.

In a favourable embodiment of the invention positive ions are deflected to one edge and negative ions to the other edge of the separation section by a magnetic field perpendicular to the direction of the gas flow. Also, absorption of the ions, which have been forced to the edge of the channel in the separation section, is prevented by charging the wall with a charge whose sign is equal to the charge of the ion. In another favourable embodiment of the invention the ions are separated into positive and negative by an electric field across the separation section, in which case the positive ions go towards one edge and the negative ions towards the other edge. In some embodiments one or more electric fields can be used and/or electric and magnetic fields at the same time.

In one favourable embodiment successive grids are placed into the channels, which are branched off from the channel that goes through the separation section, and the voltage in these grids increases from one grid to the next in positive

direction in a channel for negative ions and in negative direction in a channel for positive ions. This way the flow is made more effective.

5 In the following the invention is explained more in detail by referring to the attached drawing, in which figure 1A presents a device system for the application of the method in accordance with the invention in cross-section and seen from the side, and figure 1B presents a current spectrum obtained by a device
10 system presented in figure 1A.

In the embodiment presented in figure 1A the gas 7, which is led into the device system, is continuously ionized in the chamber 1 by an alfa radiation source. After this the gas is led into the separation section 2, where it is separated by
15 one or more electric fields or by electric and magnetic fields together so that the negative ions in this embodiment are taken to the left and the positive ions are taken to the right into the analyzing channels 3 and 4. In the analyzing channels the ions are deflected by different electric
20 fields, caused by voltages U_1-U_5 , in the channels for negative ions, and we can measure positive ion currents I_1-I_5 . In the analyzing channels for positive ions, ions are deflected by electric fields caused by voltages U_6-U_{10} , and we can measure ion currents I_6-I_{10} . The voltages in the channels can vary as
25 wanted, and also the lengths of the electric fields. The height of the channel must, however, be such, that the so called capillary forces have a strong effect on the ions, that is the ions tend to move along the center of the channel. In other words, the height of the channel is
30 preferably less than 1 mm. From the analyzing channels the gas is sucked through the air pumps 5 and 6 away from the device system.

Figure 1B presents a current spectrum obtained from measurements. In principle, a different spectrum is always

obtained with different molecules. On the basis of the current spectrum, different substances are recognized and their concentrations in the gas are determined. In this the corresponding spectra obtained by measurements with standard samples of different substances are used. If the strengths of the fields are appropriately changed, differences between differing molecule groups can be emphasized and for example different nerve gases can be detected.

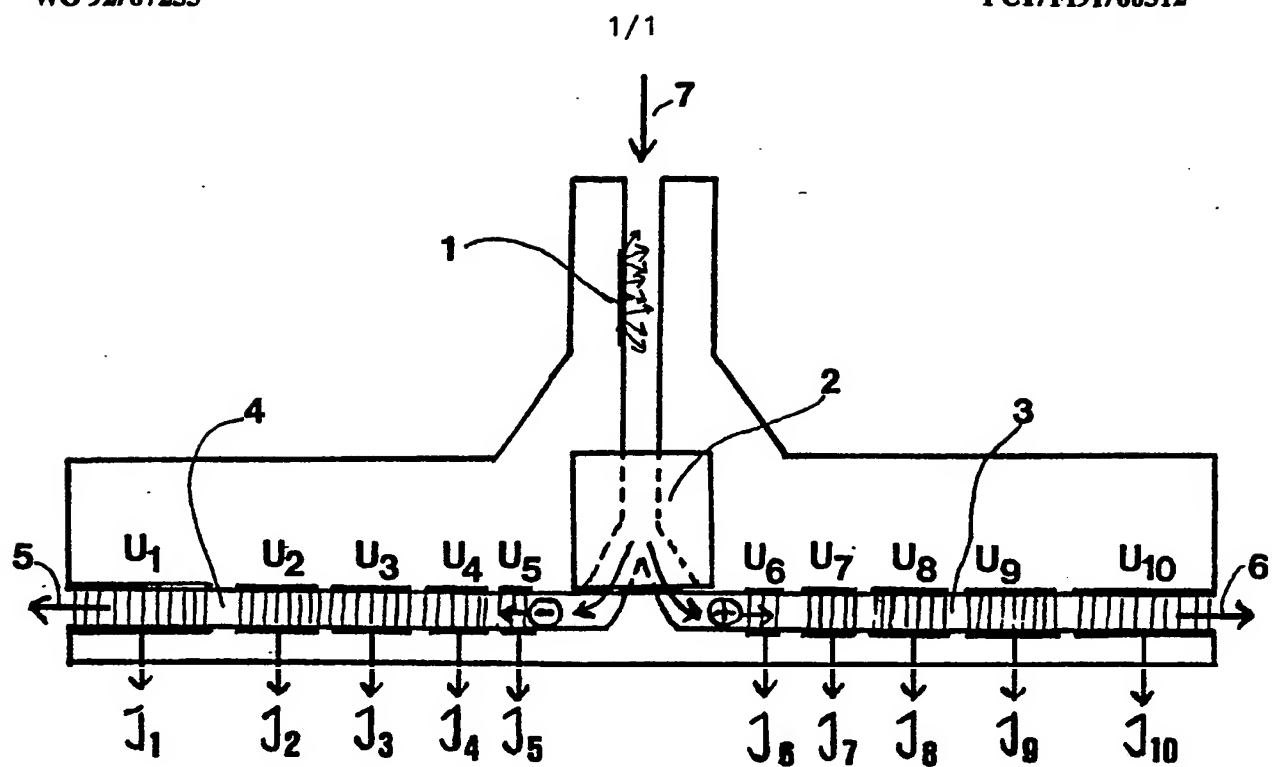
The invention is not limited to the presented example of usage, but it can further more be used in many other embodiments besides analyzing of air. Such embodiments are for example monitoring of industrial processes, where different molecules are recognized in the detectors of different chromatographs, such as liquid and gas chromatographs. The amount and values of the electric fields, and also the geometry of the device, can be varied unlimitedly. For the positive and/or negative ions two or more analyzing channels can be used, in which case also the ratios between the currents caused by ions deflected in different electric fields are measured. The separator section can also be different, the main thing is, that it separates the ions for the most part into positive and negative.

CLAIMS

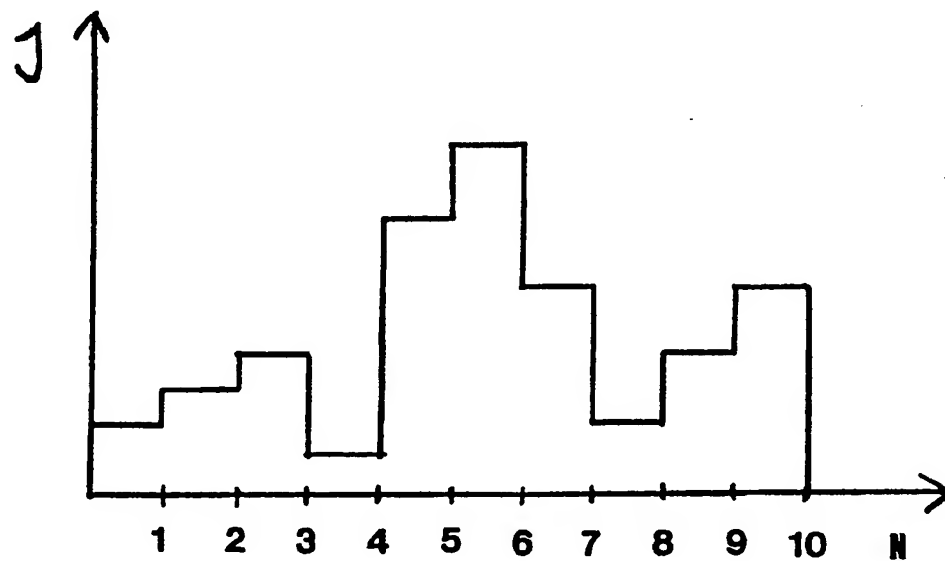
1. Method for determining of alien matter content, in which method the gas and the substances contained in it are
5 ionized in an ionization room (1), characterized in, that the ions contained in the gas are separated in a separation section (2) into positive and negative ions, of which at least the ions of either sign are led into a narrow analyzer channel (4), where they will, due to the
10 capillary force, be forced move in the middle section of the channel, from where they are deflected by electric fields of different strengths caused by different voltages (U_1-U_5) and (U_6-U_{10}) into an electrode at the edge of the channel, where they cause ion current (I_1-I_5) and (I_6-I_{10}) and that on the
15 basis of the ion currents a current spectrum is made on the basis of which different substances are recognized and their concentrations determined with the aid of corresponding spectra obtained with standard samples of different substances.
- 20
2. Method according to claim 1, characterized in, that in the separation section (2) the positive ions are deflected to one edge and the negative ions to the other edge by a magnetic field perpendicular to the direction of
25 the gas flow and absorption of ions which have been forced to edge by charging the wall with a charge of same sign as the ion has.
3. Method according to claim 1, characterized in, that as the channel of the separation section (2) branches, successive grids are placed into the branch channels, in which grids the voltage rises to positive direction in a channel for negative ions and to negative direction in a channel for positive ions when moving from
30 one grid to the next.
- 35
4. Method according to claim 1, characterized

in, that in the separation section (2) the ions are separated into positive and negative ions by a crosswise electric field, so the positive ions will move towards one edge of the channel in the separation section, and the
5 negative ions towards the othe edge.

5. Method according to some of claims 1-4, c h a r a c t e-
r i z e d in, that at least two analyzer channels are
used for both negative and positive ions, in which case also
10 the relations between currents caused by ions deflected in
different electric fields are measured.



A






B

FIG. 1

INTERNATIONAL SEARCH REPORT

International Application No **PCT/FI 91/00312**

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) ⁶ According to International Patent Classification (IPC) or to both National Classification and IPC IPC5: G 01 N 27/62, B 01 D 59/44																	
II. FIELDS SEARCHED <div style="text-align: center; border-top: 1px solid black; border-bottom: 1px solid black;">Minimum Documentation Searched⁷</div> <table style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 25%; border-bottom: 1px solid black;">Classification System</th> <th style="border-bottom: 1px solid black;">Classification Symbols</th> </tr> <tr> <td style="padding: 5px; vertical-align: top;">IPC5</td> <td style="padding: 5px; vertical-align: top;">G 01 N; B 01 D</td> </tr> </table> <div style="text-align: center; border-top: 1px solid black; border-bottom: 1px solid black;">Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in Fields Searched⁸</div> <p style="padding: 5px;">SE,DK,FI,NO classes as above</p>			Classification System	Classification Symbols	IPC5	G 01 N; B 01 D											
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IPC5	G 01 N; B 01 D																
III. DOCUMENTS CONSIDERED TO BE RELEVANT⁹ <table style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 10%; border-bottom: 1px solid black;">Category *</th> <th style="border-bottom: 1px solid black;">Citation of Document,¹¹ with indication, where appropriate, of the relevant passages¹²</th> <th style="border-bottom: 1px solid black;">Relevant to Claim No.¹³</th> </tr> <tr> <td style="text-align: center; vertical-align: top; padding: 5px;">Y</td> <td style="padding: 5px;"> WO, A1, 8707720 (PUUMALAINEN, PERTTI) 17 December 1987, see page 5, line 4 - line 33; abstract; figures 1,2 --- </td> <td style="text-align: center; vertical-align: top; padding: 5px;">1-5</td> </tr> <tr> <td style="text-align: center; vertical-align: top; padding: 5px;">Y</td> <td style="padding: 5px;"> WO, A1, 9009583 (GRASEBY IONICS LIMITED) 23 August 1990, see page 13, line 10 - line 16; page 14, line 5 - line 17; figure 1 -- </td> <td style="text-align: center; vertical-align: top; padding: 5px;">1,3-5</td> </tr> <tr> <td style="text-align: center; vertical-align: top; padding: 5px;">Y</td> <td style="padding: 5px;"> EP, A1, 0027748 (THE BENDIX CORPORATION) 29 April 1981, see page 3, line 16 - line 29; page 4, line 26 - line 36; figure 1 -- </td> <td style="text-align: center; vertical-align: top; padding: 5px;">1,3-5</td> </tr> <tr> <td style="text-align: center; vertical-align: top; padding: 5px;">Y</td> <td style="padding: 5px;"> US, A, 2422264 (R.V. SEAMAN) 17 June 1947, see column 1, line 41 - column 2, line 36; figure 1 -- ----- </td> <td style="text-align: center; vertical-align: top; padding: 5px;">1,2</td> </tr> </table>			Category *	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³	Y	WO, A1, 8707720 (PUUMALAINEN, PERTTI) 17 December 1987, see page 5, line 4 - line 33; abstract; figures 1,2 ---	1-5	Y	WO, A1, 9009583 (GRASEBY IONICS LIMITED) 23 August 1990, see page 13, line 10 - line 16; page 14, line 5 - line 17; figure 1 --	1,3-5	Y	EP, A1, 0027748 (THE BENDIX CORPORATION) 29 April 1981, see page 3, line 16 - line 29; page 4, line 26 - line 36; figure 1 --	1,3-5	Y	US, A, 2422264 (R.V. SEAMAN) 17 June 1947, see column 1, line 41 - column 2, line 36; figure 1 -- -----	1,2
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<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p>* Special categories of cited documents:¹⁰</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 45%;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance, the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance, the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"&" document member of the same patent family</p> </div> </div>																	
IV. CERTIFICATION <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; border-bottom: 1px solid black; padding: 5px;"> Date of the Actual Completion of the International Search 17th January 1992 </td> <td style="width: 50%; border-bottom: 1px solid black; padding: 5px;"> Date of Mailing of this International Search Report 1992 -01- 21 </td> </tr> <tr> <td style="border-bottom: 1px solid black; padding: 5px;"> International Searching Authority <div style="text-align: center;">SWEDISH PATENT OFFICE</div> </td> <td style="border-bottom: 1px solid black; padding: 5px;"> Signature of Authorized Officer <div style="text-align: center;">  Gunnel Wasterlid </div> </td> </tr> </table>			Date of the Actual Completion of the International Search 17th January 1992	Date of Mailing of this International Search Report 1992 -01- 21	International Searching Authority <div style="text-align: center;">SWEDISH PATENT OFFICE</div>	Signature of Authorized Officer <div style="text-align: center;">  Gunnel Wasterlid </div>											
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**ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO.PCT/FI 91/00312**

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the Swedish Patent Office EDP file on 30/11/91. The Swedish Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO-A1- 8707720	87-12-17	AU-B- 605770	91-01-24
		AU-D- 7517787	88-01-11
		EP-A- 0308420	89-03-29
		US-A- 5047723	91-09-10
WO-A1- 9009583	90-08-23	EP-A- 0456700	91-11-21
		GB-A- 2228139	90-08-15
EP-A1- 0027748	81-04-29	CA-A- 1146632	83-05-17
		US-A- 4445038	84-04-24
US-A- 2422264	47-06-17	NONE	